

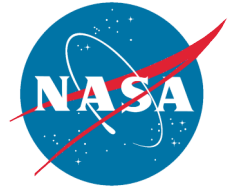
Breakout Session Summary:

Detectors and Sensors

Co-chair: Cheryl Marshall (NASA-GSFC)

Co-chair: Heidi Becker (JPL)

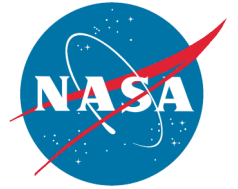
**SET-3 Requirements Workshop
March 29-30, 2007**



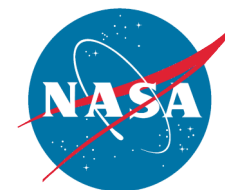
Why Study Detectors & Sensors?

- **UV/Visible focal plane array (FPA) technologies identified as critical to the NASA mission yet they are inherently sensitive to radiation**
 - **NASA Office of Space Science roadmapping effort**
- **Technologies discussed include: Charge coupled devices (CCDs), active pixel sensors (APS), p-CCDs, avalanche photodiodes (APDs), Si hybrids, microchannel plates (MCPs), InGaAs, InSb, HgCdTe Si:As, TES, microbolometers, solar cells, optocouplers and fiber optic links.**
- **Investigations require exposure to solar-variant environment**
 - **Solar events can drive the total ionizing dose, displacement damage and single event transient effects of a sensor**

Background

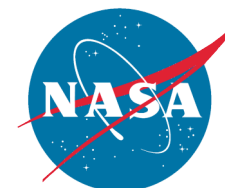


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- Unlike most microelectronic devices, many sensors are highly susceptible to displacement damage effects.
 - They may also be susceptible to total ionizing dose and single event transients.
 - Protons and secondaries create lattice defects that increase the dark current, reduce CTE in CCDs, and produce hot pixels
 - Secondaries are produced in the heavy shielding/spacecraft often required for sensor survivability on-orbit
 - Uncertainties in the sensor degradation models result in large radiation design margins (RDM) for a soft technology
 - In some cases the mechanisms are not understood.
 - Gaps also exist in the understanding of on-orbit data such as the production/annealing of hot pixels on the ACS/HST.



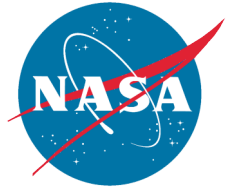
Background, cont.

- **Three proposals were presented followed by general discussion**
 - **Prediction of on-orbit solar cell degradation and comparison with space data**
 - **Modeling of charge deposition transients in detectors and comparison with on-orbit data**
 - **Analysis on on-orbit star tracker data from selected missions**
- **Space “data mining” would be facilitated by a detailed catalog of available data sets.**



Prioritized Topics

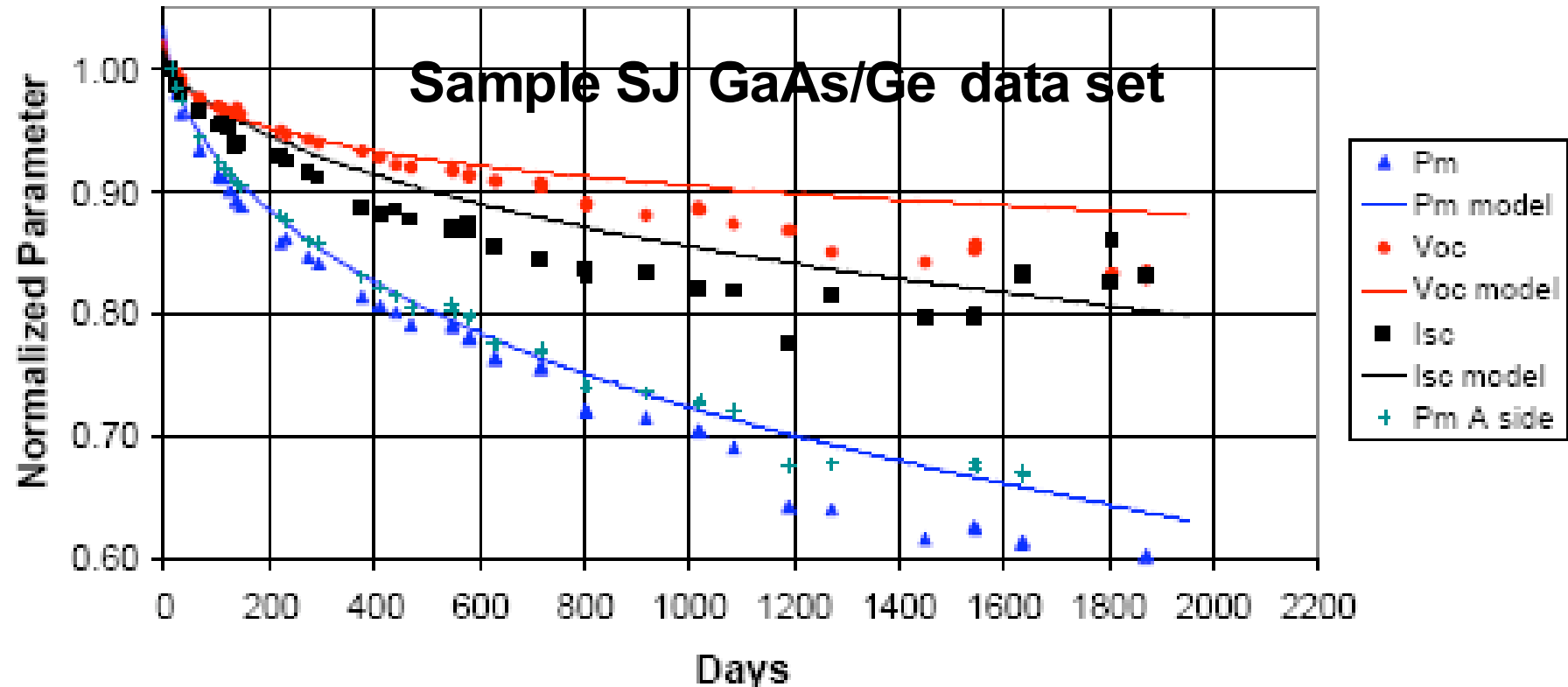
- **Catalogue of Available Space Data**
 - Information would include: sensor type, sensor operating conditions, orbit data, operational lifetime within the solar cycle, and data integrity and availability
 - Examples include:
 - Visible/NIR: SOHO/LASCO, SOHO/MDI, STIS, startrackers
 - X-ray: Chandra, Yohkoh, GOES-SXI
 - EUV: Trace, SOHO/EIT
 - IR: NICMOS, ISO-CAM, Spitzer
 - Solar Cells: PASP-Plus, ASCOT, TacSAT-4
 - One critical issue is to have access to raw data.
 - Cosmic ray transients may be of interest yet are often scrubbed from astronomy data



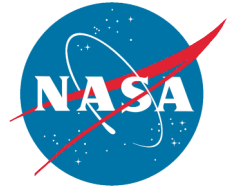
Displacement Damage Effects in Solar Cells: Mining DATA from 3 Space Experiments

- Previous NRA yielded beta version of Solar Array Analysis and Verification Tool (SAVANT) code to predict on-orbit solar cell degradation
 - Code was benchmarked against MPTB data
- Needed investigation will:
 - validate against 3 dedicated space experiments
 - Variety of Si, GaAs and multi-junction cells
 - Complete solar cells IV data available
 - Complementary dosimetry data available
- Data will be correlated to existing environmental models to modify engineering tool for improved on-orbit predictions and accurate solar array trade studies.
 - Mission cost savings through improved power prediction and associated reduction in design margin requirements
- Develop user friendly Windows based code to meet industry and government requirements for solar cell qualification (e.g. AIAA).

Advanced Solar Cell Orbital Test (ASCOT)



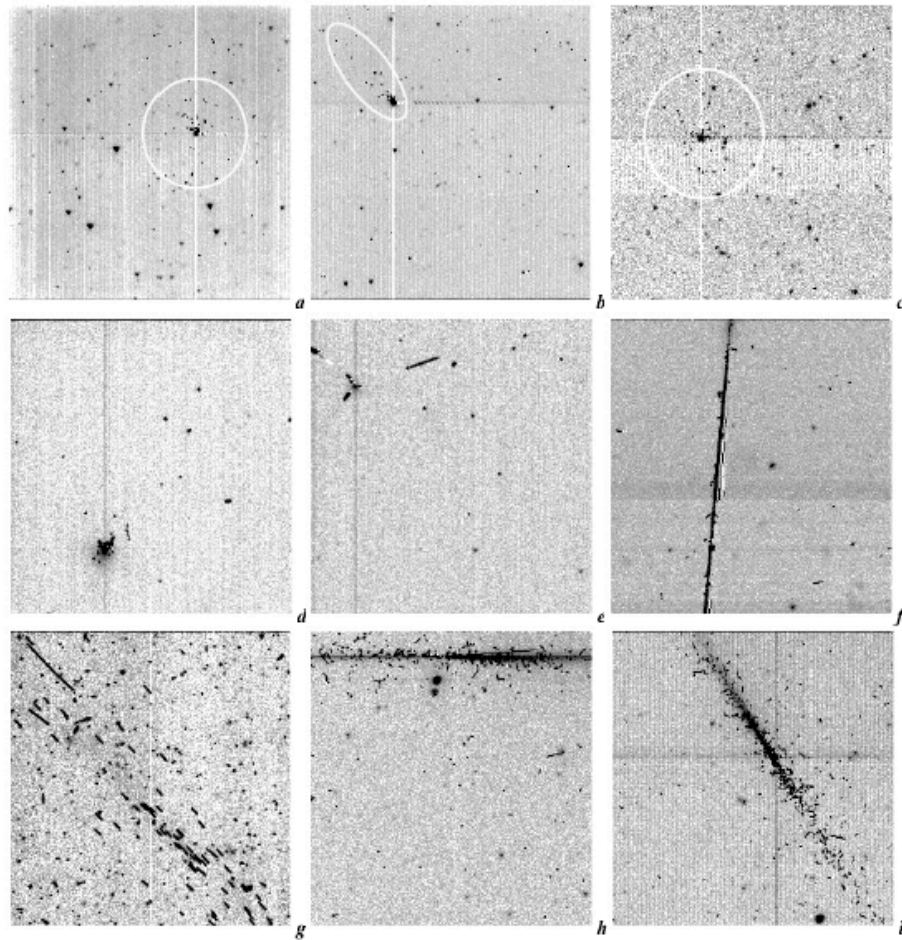
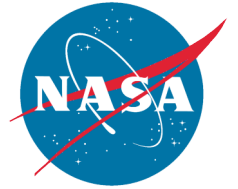
- This calculation used the standard NASA AP8/AE8 radiation models. The calculation is reasonable for the Max Power (Pm) but not for Voc and Isc. On-orbit dosimetric data was not employed at this time. (Taken from Marvin, Proc. 4th WCPEC, Waikoloa, HI 2006, p.2023)



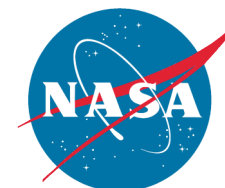
Secondary Particle Effects on Single Event Transients (SET) in Sensors

- Previous NRA developed REACT code to model transient charge deposition in sensors which was benchmarked against James Webb Space Telescope (JWST) HgCdTe sensor ground data.
- The SET data base on SPITZER and other space based sensors (e.g. SOHO) are mined and compared to emerging models for SET to include secondary particle effects which are important for emerging low noise applications.
 - IR detector arrays in space are excellent source of data on primary and secondary particle interactions because of well-defined volumes and low noise floors which facilitate model validation.
 - Results also applicable to emerging issues in SEE in microelectronics
 - Enhanced model will include the secondary production physics in Geant4.

SPITZER Images from InSb and Si:As Arrays

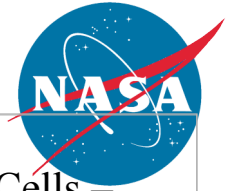


After Patten

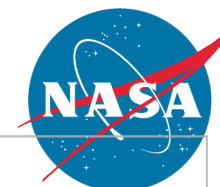


Investigation of on-Orbit Star tracker Data

- To date CCDs are flown on most satellites as star trackers.
- Onboard data from multiple orbits is available in a raw form to discern detector performance, in particular, ion transients.
 - Useful to benchmark models used for noise rejection algorithms, etc. in order to improve the accuracy of these instruments.
 - Would like to investigate occurrence of electron and proton noise and event rates correlated with tracker performance accuracy.
 - Data is time-tagged.



Technology Breakout Session (Check One): <input type="checkbox"/> Environment Specification <input type="checkbox"/> Microelectronics <input type="checkbox"/> Materials <input checked="" type="checkbox"/> Sensors & Detectors <input type="checkbox"/> Charging/Discharging	Title of Issue Requiring Investigation: Displacement Damage Effects in Solar Cells – Data Mining from the ASCOT, PASP-Plus and TacSat-4 Space Experiments
Background: NRL has developed a displacement damage dose (Dd) methodology that enables correlation of displacement damage effects over a wide range of particles and energies. Based on the Dd methodology, NRL has created a physics-based method for analyzing solar cell radiation response data and making on-orbit performance predictions. Compared to existing methods, the Dd method is more robust and efficient to implement in terms of required ground test data. Under the first LWS SET, NRL and NASA GRC mined space solar cell data and on orbit dosimetry measurements from the MPTB mission to produce the Solar Array Verification and Analysis Tool (SAVANT), which is designed to be a distributable code for implementation of the method. The result was a beta-version. Here we propose to mine three other space experiments to further validate the method and correlate the solar cell performance with on-board dosimetry data. The project will produce an improved version of SAVANT that operates as a user-friendly, stand-alone, executable code that can be widely distributed or integrated into larger environmental analysis suites like SPENVIS and EWB. The space solar cell community would greatly benefit from this.	
Description of Needed Investigation: An analysis of on orbit data from three experiments (PASP-Plus, ASCOT, and TacSat-4) is needed. These include both solar cell and radiation environment measurements along with a full complement of ground test data. The solar cell data needed to be analyzed to produce power output as a function of time on orbit. The environment measurement data need to be analyzed to produce absorbed Dd as a function of time on orbit. Combining these produces power output as a function of Dd on orbit. The ground test data must be analyzed to produce degradation curves as a function of Dd for each solar cell technology under study. Similarly, existing environment models need to be exercised to produce predictions of the absorbed Dd as a function of mission duration. The Dd method will then be used to make on orbit performance predictions. Comparison of these predictions with the on orbit data will allow validation and refinement of both the solar cell performance model and the environment models. The analyses will be made within a computational environment that facilitates transition to a distributable, stand-alone executable file. Note that solar cell analyses in this way can be used to validate new environment models.	
Justification: This proposal directly addresses the LWS SET goal to produce an improved design and operations model and database from the analysis of existing in-space flight data. This investigation will create a product that better characterizes the environment in the presence of a spacecraft and performs better predictions of hardware performance (i.e. the power system) in the space environment. This proposal addresses two of the focused technology categories: the environment in the presence of the spacecraft and effects on detectors and sensor technologies.	
Benefiting Technology Areas: The environment in the presence of the spacecraft Effects on detectors and sensor technologies	Benefiting Space Application Areas: All missions in a radiation environment powered by photovoltaics
Investigation Resource Requirements: Data Access Requirements (data name, cost): :	Submitter Information: Name: Dr. Scott Messenger



Technology Breakout Session (Check One): <input type="checkbox"/> Environment Specification <input type="checkbox"/> Microelectronics <input type="checkbox"/> Materials <input checked="" type="checkbox"/> Sensors & Detectors <input type="checkbox"/> Charging/Discharging	Title of Issue Requiring Investigation: Secondary Particle Effects on SET in Sensors and Microelectronics
Background: Secondary particles are becoming more important for consideration in modeling with increasingly scaled microelectronics and more sensitive detectors. IR detector arrays in space are source of data on primary and secondary particle interactions with well-defined volumes and low noise floor. SET database on SPITZER and other space-based sensors should be mined and compared to emerging models for SET and SEU. On-going modeling development for SET/SEU that need to consider secondary particle effects include the REACT tools for sensors that were developed on the JWST Program, the MRED tools for SEE that are being developed by Vanderbilt University, modifications and upgrades to the CRÈME program for SEE rate prediction, and others.	
Description of Needed Investigation: The proposed investigation includes the following steps: (1) Acquire space SET data from SPITZER, TX/MPTB, ACS/Hubble and other applicable sources; (2) Analyze data and compare to REACT, MRED, CRÈME and other applicable models; (3) Improve models as appropriate.	
Justification: Validated models are essential for enabling system design and cost-effective mitigation of SEE in microelectronics and sensors.	
Benefiting Technology Areas: Sensor design for space-based astronomy and missile defense surveillance and tracking. Microelectronics SEE rate prediction and SEE hardening.	Benefiting Space Application Areas: NASA, DoD, Commercial Space Industry
Investigation Resource Requirements: Data Access Requirements (data name, cost):	Submitter Information: Name: James C. Pickel